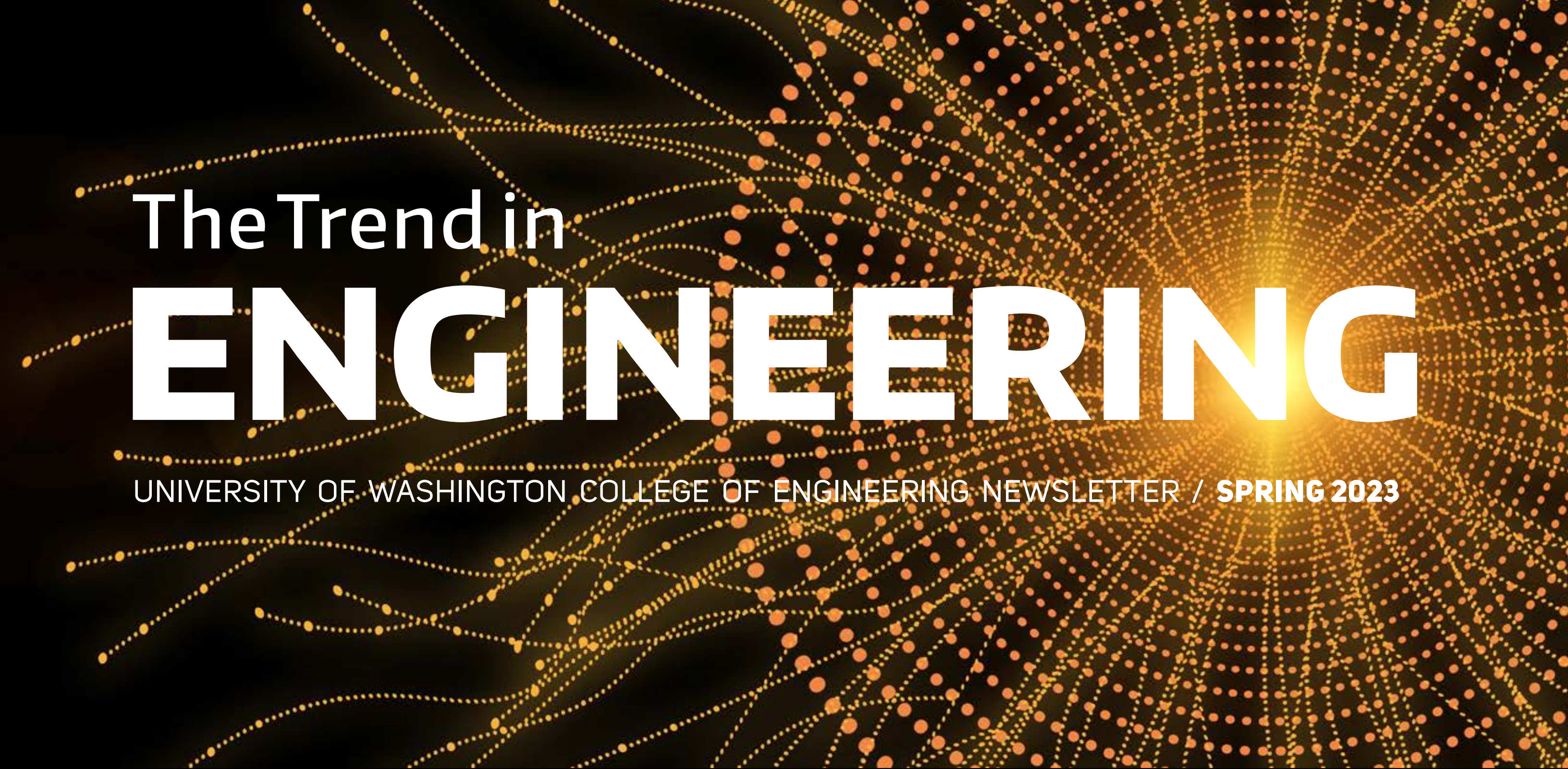

The Trend in

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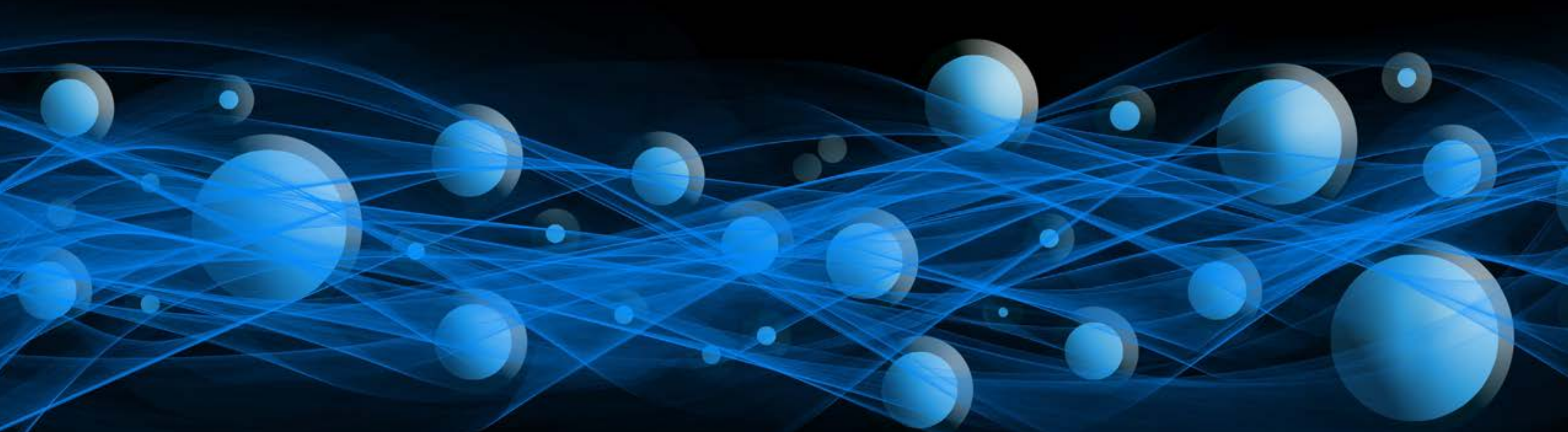
UNIVERSITY OF WASHINGTON COLLEGE OF ENGINEERING NEWSLETTER / **SPRING 2023**



UW Engineering leaders explain why quantum matters now

PAGES 4-7

FROM THE **DEAN**

In August 2022, the federal government passed the $250 billion CHIPS and Science Act to reaffirm America's commitment to domestically manufacturing semiconductor chips and to innovating the next-generation technologies we need to be competitive. The CHIPS and Science Act presents an incredible, once-in-a-generation opportunity, and universities will be critical to meeting the nation's ambitious goals.

The semiconductor industry is poised to grow rapidly in the U.S., but it faces intense deficiencies in the size and diversity of the workforce. Tackling these barriers requires a national mobilization that maximizes the potential of higher education in growing and diversifying the workforce — and connecting the skills and knowledge of this workforce with the industry partners who need them.

To answer this call, UW President Ana Mari Cauce and I joined a group of women presidents and deans of engineering of the Association of American Universities (AAU). We are working as a team of institutions to create and implement a set of goals to expand and diversify the semiconductor workforce. AAU institutions are leaders in innovation, scholarship and solutions that contribute to scientific progress, economic development, security and well-being. Each of our universities is engaged in education and research associated with the semiconductor industry and is committed to advancing women and underrepresented populations in science and engineering.

The CHIPS and Science Act also focuses on the development of next-generation technologies, which includes quantum information science and engineering. Since 2020, the UW has been accelerating quantum research to establish our university as a global leader in this space. Like the semiconductor industry, quantum information science and engineering is rapidly growing and also faces an unprepared, limited workforce.

This is where institutions like the UW can play a critical role. In this issue, I am joined by two of our amazing UW quantum experts, Professors Kai-Mei Fu and Charles Marcus, on why it's important to support quantum research now. I know that quantum can be a challenging topic to wrap our minds around; our hope is that we can help unpack why it matters — for the UW, the state of Washington and the world.

Nancy Allbritton, M.D., Ph.D.
Frank & Julie Jungers Dean of Engineering

2023 DIAMOND AWARDS

The College of Engineering honors four alumni for their outstanding achievements and contributions in the following areas:

EMBRACING THE POWER OF DIVERSITY, EQUITY AND INCLUSION (DEI)

Steve Chisholm, B.S. '86 Mechanical Engineering
Vice President, Mechanical & Structural Functional Chief Engineer, The Boeing Company

CREATING A HEALTHIER AND MORE JUST WORLD

Dwayne Dunaway, M.S. '94, Ph.D. '01 Bioengineering
Chief Research Engineer and Co-Founder, NanoString Technologies

TRANSLATING INNOVATION INTO IMPACT

Alain Adjorlolo, B.S. '79, M.S. '81, Ph.D. '85 Materials Science & Engineering
Project Engineer, Lead, Advanced Materials, The Boeing Company

DEAN'S AWARD

Anne Dinning, B.S. '84 Computer Science & Engineering
Managing Director and Executive Committee member, the D. E. Shaw Group

DIAMOND
AWARDS

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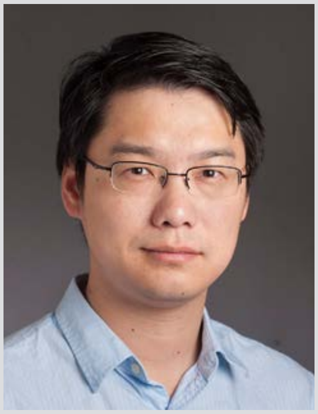

Di Xiao to serve as chair of Materials Science & Engineering

We welcomed Di Xiao, Campbell Chair in the College of Engineering, to the position of chair of the Department of Materials Science & Engineering (MSE) in March.

Xiao is a renowned theorist in the field of quantum materials. He is a pioneer in the fields of quantum valleytronics, two-dimensional (2D) van der Waals magnets, and the application of novel topological phase effects in 2D quantum materials. He has been named a Thomson-Reuters Highly Cited Researcher every year since 2017, with his work cited over 46,000 times.

Xiao joined the UW in 2021. He has a joint appointment with MSE, physics and the Pacific Northwest National Laboratory. Previously, he was a professor of physics at Carnegie Mellon University. He is a Fellow of the American Physical Society, a Simons Fellow in Theoretical Physics, and a Clarivate Highly Cited Researcher. He brings significant leadership and service experience to this role and is a collaborative leader with a compelling plan to work with the MSE community to build a shared and inclusive vision for the department.

UW Engineering named a national leader in inclusive excellence

The College of Engineering has been recognized as a leader in inclusive excellence by the American Society for Engineering Education (ASEE). The College's Office of Inclusive Excellence received the ASEE's Bronze diversity recognition award in December.

"Inclusive excellence fosters student development within STEM, but more importantly equity and belonging," says Karen Thomas-Brown, the College's associate dean of diversity and inclusion. "Employers have been expressing a desire to hire engineers with different perspectives and with cross-cultural soft skills. Engineers are increasingly expected to work with teams located across the world."

The team earned the ASEE award in part for their efforts to include student input in the design of the new Interdisciplinary Engineering Building. Student feedback shifted the final design plan to include wall art, designated rooms for student affinity groups, a prayer room and a lactation room.

The collaboration between the building's planners and UW students is a model for Thomas-Brown's vision for inclusive innovation.

"It is absolutely critical that in an education for engineers we elevate the notion of diversity, equity and inclusion because engineers innovate for our diverse world," says Thomas-Brown, who leads the Office of Inclusive Excellence. "We won this award because we have a strong strategic plan with measurable goals to make this vision a reality."

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Why QUANTUM matters

Three UW Engineering leaders share their thoughts on the potential of quantum research, and why it's so important now.

Nancy Allbritton

Frank and Julie Jungers Dean of the College of Engineering

Why is quantum such a big deal?

Some may remember when the personal computer and classical computing emerged in the 1980s. They changed nearly everything. Recent advances in quantum research promise breakthroughs that will also fundamentally change how we live and work. It can help us address major societal issues, and it promises economic benefit.

The U.S. government has identified quantum as a key technology investment area. Congress signed the National Quantum Initiative Act into law in 2018, and the CHIPS and Science Act will boost federal quantum investment. U.S. Secretary of Commerce Gina Raimondo recently called on universities to triple their graduation of new engineers over the next decade as part of the long-term vision for America's technological leadership. This is a call to unite behind a shared objective, think boldly and mobilize public-private partnerships. I believe that because of its strong ties between research universities and industry, the U.S. — and the state of Washington in particular — is poised to be a quantum leader.

What are the challenges?

Competition for talent and funding is aggressive. Governments and industries worldwide are making big investments

Nancy Allbritton testifies on U.S. leadership and emerging technologies before the U.S. Senate Committee on Commerce, Science and Transportation in September 2022.

to lead in this area. Only a few universities across the globe have quantum programs, but that is quickly changing.

Another big issue is the lack of a prepared quantum workforce. Companies already have a difficult time filling skilled STEM jobs. This is further complicated when jobs require advanced degrees in physics, chemistry, materials science, engineering and computer science. Universities, governments and private companies must partner to expand the number of quantum-trained professionals. In Washington, workforce development will have a major impact on established companies as well as on emerging start-ups and companies that don't even exist yet.

How is the UW working to advance quantum?

The UW can provide leadership, research and workforce education. Thanks to support from the UW President and Provost, this institution has been growing its quantum information science and engineering programs across the College of Engineering and College of Arts & Sciences. It has strong roots in quantum discovery, too: not one but two UW scientists have received the Nobel Prize in Physics for quantum research — Hans Dehmelt in 1989 and David Thouless in 2016.

Today many of our quantum researchers are recognized as global leaders. Thanks to collaborations with industry partners — including Microsoft, Boeing, Google and Amazon — and with the Pacific Northwest National Laboratory (PNNL), they have been advancing quantum research and teaching.

Why is it important to invest in quantum research and education at the UW and in Washington?

We need to prepare students for jobs within quantum information science and engineering. And we need to support research that helps promote economic and national security while expanding the talent pool for current and future industries here in Washington.

The competition to develop "Quantum Valley" is heating up. It will require the sort of outlook and investment that paved the way for Silicon Valley in California. This won't happen overnight, but we need to start building it now.

Kai-Mei Fu

Professor of electrical and computer engineering and of physics

QuantumX Co-Chair

What is "quantum?"

Originally, "quantum" just meant "discrete." It referred to the observation that, at really small scales, something can exist only in discrete states. This is different from our everyday experiences. For example, if you start a car and then accelerate, the car "accesses" every speed. It can occupy any position. But when you get down to these really small systems — unusually small — you start to see that every "position" may not be accessible. Similarly, every speed or energy state may not be accessible. Things are "quantized" at this level.

That's not the only weird thing: At this small scale, not only do things exist in discrete states, but it's possible for things to exist in a combination of two or more different states at once. This is called "superposition."

How is superposition useful in developing quantum technology?

Let's take quantum computing. In the information age of today, a computational "bit" can only exist in one of two possible states: 0 and 1. But with superposition, you could have a "qubit" that can exist in two different states at the same time. It's not just that you don't know which state it's in. It really is coexisting in two different states. Thus, it's possible to compute with many states, in fact exponentially many states, simultaneously. The power is in being able to control that superposition.

What are some advancements that could stem from controlling superposition?

There are four main areas of excitement. My favorite is probably quantum computation. We know that the power of quantum computation will be immense because superposition is scalable. This means that you would have much more computational space to utilize, and you could perform computations that our classical computers would need the age of the universe to perform. So, we know that there's a lot of power in quantum computing. But there's also a lot of speculation in this field, and questions about how you can harness that power.

Besides quantum computing, what other applications are there?

Another area is sensing for more precise measurements. For my research, I work with atoms arranged into a perfect crystal. Then I create "defects" which act like artificial atoms and react to tiny changes nearby — amplifying the changes into something I can see. I get excited because we know that all these things are possible in theory, but we've just hit the timescale where we're starting to see real technological applications.

Kai-Mei Fu at work in the Quantum Defect Laboratory, which she directs at the UW. Photo by Dennis Wise

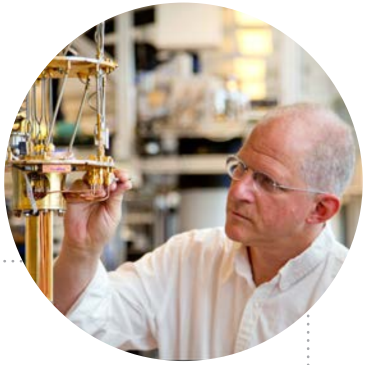
Another area is quantum simulation. There are many potential applications in this field, such as studying new energy storage systems or making an enzyme better at nitrogen fixation. Essentially these problems require making new materials and are too hard for classical computers to simulate or predict. But quantum simulation could, using a quantum computer.

The final area is quantum communication. When you're transmitting sensitive information, you can create a key to encrypt it. With quantum encryption you can distribute a key so fundamentally secure that if you have an eavesdropper, they leave a "mark" that you can detect.

What's happening in terms of quantum education?

We're crafting a common framework and language for quantum education. Quantum involves many fields, including chemistry, computer science, material science, chemical engineering and theoretical physics. Historically these fields have had their own approach and vocabulary. At the UW, we've launched a core curriculum in quantum for graduate students who want to pursue careers in this field. Through the Northwest Quantum Nexus, we also have partners for internships. And while we don't currently have a quantum computer on campus, we are gathering materials to construct a quantum processor — the basis of a quantum computer — as part of our educational curriculum.

We need more scientists in quantum. There are too many questions to answer, and every field in quantum is growing. It's going to change how we approach problems — in communication, in software, in medicine and in materials. It will be beyond what we can think about today.



Charles Marcus adjusts equipment at the Niels Bohr Institute in Copenhagen, Denmark. Photo by Ola Joensen / Niels Bohr Institute

Charles Marcus

Professor of materials science and engineering and of physics

Why are we hearing so much about quantum now?

Two important things have happened in the last 10 years. One is that experimental control over quantum mechanics systems has emerged and become highly developed. In other words, how to "do" quantum research has become more feasible. The other is that progress has been made in terms of how to use quantum computers to solve important societal problems. For a long time, people didn't know how to use these machines, but that's changed.

It's generally uncommon to develop new technology and its applications simultaneously. For example, we developed lasers then figured out how to use them. With flight, we established a need then came up with the technology to achieve it. With quantum, these have co-evolved over the last two decades. The last decade especially has seen a big influx in participants and in the idea that the frontier is expanding across all areas of quantum, not just computing.

What's happening at the UW that makes it an exciting time to be here?

It is a remarkably exciting time! Over the last few years, the UW has hired several early and mid-career faculty across several disciplines. And the UW is encouraging and supporting collaborative quantum research. This research doesn't reside in one department but across several. This is a major strength, and it means that something catalytic can occur.

You've led quantum research at several organizations, including Harvard University, Microsoft and the University of Copenhagen. What are you most looking forward to now that you've joined the UW faculty?

Honestly, there's no place else I'd rather be. I'm eager to be part of the growing cluster of quantum researchers at the UW. Cooperation over competition was very much a part of the culture at the Niels Bohr Institute, where I taught at the University of Copenhagen. There, researchers work together to advance a common interest. I want to help encourage and expand a similar approach to collaboration here. I'm excited to shepherd exchange between the UW and University of Copenhagen — in terms of research collaboration, equipment sharing and more.

Why is it critical for academia, industry and government to be in sync about quantum?

The quantum field is in its infancy. As it develops it will require a big shift in how we think about innovation, which has traditionally followed a linear path: Government funds research, which takes place in academia and eventually is spun out and taken to market by industry.

With quantum, not only is it essential that an academic-industry-government relationship exists, but that all partners recognize it as cyclical. Some readers may remember the 1979 book “Gödel, Escher, Bach: An Eternal Golden Braid” by Douglas Hofstadter. It gives us a good metaphor to apply here. With quantum, we can consider another type of braid: education, government and business — quantum must consistently be a braid of these that is always renewing and recursive, not driven toward a single, linear destination.

Why is it important that this work be situated in the Pacific Northwest?

This area has the right ratio of hard sciences, medical sciences, engineering and advanced information technology. It’s not Silicon Valley here, it’s something else. And the relationship between universities and business is strong. There’s a lot of energy and a lot of seeds that have been planted — for example, by Kai-Mei Fu and others who’ve established QuantumX, a campus hub for research, teaching and commercialization across all areas of quantum.

The real answer to what quantum computers can do is “no one knows.” But the Pacific Northwest is a high tech leader, and the interface between science and technology is strong. In many ways, the UW will be the engine driving this work.

Quantum all-stars

In the last two years, these rising and established researchers have joined the stellar UW quantum information science and engineering faculty through a cluster hire investment:

Andrea Coladangelo, assistant professor
Paul G. Allen School of Computer Science & Engineering

Serena Eley, assistant professor
Electrical & Computer Engineering

Juan Carlos Idrobo, professor
Materials Science & Engineering

Charles Marcus, professor
Materials Science & Engineering and Physics

Sara Mouradian, assistant professor
Electrical & Computer Engineering

Rahul Trivedi, assistant professor
Electrical & Computer Engineering

Di Xiao, professor
Materials Science & Engineering and Physics

Accelerating a quantum future

Learn more about how our researchers are helping to establish the UW as a global leader of the coming quantum age.

engr.uw.edu/quantum-future

When it comes to cardiac systems research, Patrick Boyle wants to play his cards right.

Research

By Chelsea Yates

Growing up, Patrick Boyle loved playing cards with his family and named his UW research laboratory — the Cardiac Systems Simulation (CardSS) Lab — in part to honor the pastime. But a more surprising connection between family and research was still to come.

“I don’t know how many people in my line of work have the opportunity for their research to manifest in front of their eyes, in a loved one no less,” the assistant professor of bioengineering says. “It’s been surreal and humbling.”

In the CardSS Lab, Boyle’s team models heart rhythm disorders to help doctors better understand and predict when patients may be at risk of arrhythmia, cardiac arrest and stroke. Central to their work is atrial fibrillation (A-fib), a type of arrhythmia that’s very common —

the Centers for Disease Control and Prevention (CDC) estimates that 12.1 million people in the U.S. will have A-fib by 2030 — yet difficult to detect.

"It's tricky to diagnose because in many cases A-fib can occur spontaneously without any sign something might be amiss," Boyle explains. "Some people have persistent episodes and are well aware of their condition, but for others it comes and goes. Episodes of A-fib can cause shortness of breath or palpitations, but many folks have no symptoms whatsoever, which makes those occurrences especially challenging to catch."

With monitoring and treatment, people with A-fib can live regular lives. Left untreated, it can increase a person's risk of stroke. During an episode, the heart's upper chambers beat irregularly and out of sync with the lower chambers, which can lead to blood clots in the heart. According to the CDC, A-fib is the cause of one in seven strokes, yet many people don't discover they have A-fib until something significant like a stroke occurs.

For years, Boyle has been working to draw more attention to the correlation between A-fib and stroke and improving A-fib screening and treatment using cutting-edge bioengineering tools and techniques.

Even so, he wasn't prepared when, last September, his dad experienced what would be the first of two strokes — and a perspective shift on his own research was in the cards.

ENGINEERING AND HEART HEALTH

The Cardiac Systems Simulation (CardSS) Lab uses MRI scans, computer models and other tools to learn more about heart rhythm disorders and to develop new treatment strategies. Learn more at **cardsslab.org**

Opposite page: Patrick Boyle, center, with bioengineering Ph.D. candidate Alexander Ochs, left, and junior Jamie Yang, right, in the CardSS Lab. Photo by Mark Stone

from the **heart**

TWO STROKES IN FIVE DAYS

Boyle was preparing to travel out of the country when he received a call about his dad. His parents had been driving from their home in Calgary to Seattle when Boyle's father lost the peripheral vision on his right side.

"Somewhere between Spokane and Seattle, he'd had a stroke, but we didn't realize that yet," Boyle says. "His symptoms were minimal. Honestly Dad seemed more annoyed about the whole thing than concerned."

After seeking medical care in Seattle, the team quickly confirmed a stroke. Following an overnight stay and several diagnostic tests, he was discharged on a dual antiplatelet therapy (DAPT) course of treatment to prevent an unwanted clot. After a few days of rest, Boyle and his brother drove their parents home.

About an hour from Calgary, Boyle's father unexpectedly suffered another stroke, this one much more serious than the first. This time the symptoms were on his left side — a sign that this stroke was affecting different territory in his brain than the first one. An ambulance rushed him to the hospital, where he had a blood clot removed from his brain via an endovascular thrombectomy (EVT) procedure.

Within an hour Boyle's father seemed nearly back to normal and able to move his left side with surprisingly few limitations.

"His pre- and post-EVT scores on the NIH stroke scale were 14 and 3. That scale goes from 0 to 42. If what I saw in Dad was a 14, I never need to see anything above that," Boyle says.

A SURPRISING DISCOVERY

Due to capacity issues in the stroke recovery unit, medical staff kept Boyle's father in the emergency department, which would prove important. On Boyle's watch, a few days later, his dad's ECG heart monitor started flashing "AFIB."

"He didn't have a known history of A-fib, and there had been no physical change," Boyle says. "I notified a nurse, who called in the electrocardiography team to confirm that he was definitely in A-fib."

"I don't know how many people in my line of work have the opportunity for their research to manifest in front of their eyes, in a loved one no less. It's been surreal and humbling."

– Patrick Boyle, *assistant professor of bioengineering*

They could see on the heart monitor that his heart rate had abruptly increased by about fifty percent, but he felt nothing different. "This is a message my lab and I have been sharing for years — A-fib is insidious because people can be in it but have no idea — and here it was, right in front of me, happening to my dad," Boyle says.

It's also possibly why Boyle's father experienced two very different strokes in five days. During A-fib, blood clots created near the heart can be released. Depending on their size and if they make their way to the brain, they can cause a stroke, which is what doctors believe happened during the second stroke. While there was no clinical documentation of arrhythmia from the hospital in Seattle, Boyle believes the evidence points in that direction.

In a way, the discovery was uncanny. "Had he been transferred out of the emergency department, the nurses told me they likely wouldn't have had him on an ECG because other units don't routinely monitor the heart, and so we likely wouldn't have known he was experiencing an episode at all," Boyle says.

'A RENEWED VIGOR'

Adjusting to life with a heart condition, Boyle's father is now on an anticoagulant to minimize the stroke risk. He's been using his smartphone to track his heart rhythm since he doesn't feel different during an episode. Boyle says his dad has tracked about eight, each lasting anywhere from one to eight hours. Activities such as meditation and walking have helped him come out of an episode.

For Boyle, the experience has brought a major shift in his approach to research and teaching.

"Dad's episode was precisely the kind of ESUS [Embolic Stroke of Undetermined Source] that motivates a large part our lab's work," he says. "Imagine if we had better tools to help decide whether someone who's had a stroke like Dad's first one should be sent home on DAPT or if it's warranted to use a stronger drug like an anticoagulant earlier on, despite the increased risk."

Boyle is encouraging his students to broaden their view.

"We need to ask different questions and figure out better ways to bring our research to the bedside," he says.

A big part of this is expanding collaborations between physicians and engineers. At the UW, Boyle works closely with Dr. Nazem Akoum, a cardiac electrophysiologist who directs the atrial fibrillation program at UW Medicine, to use data from A-fib patients' MRI scans to run simulations that can inform new treatment strategies. He also works with Juan Carlos del Álamo, a professor of mechanical engineering who specializes in cardiac biomechanics and fluid dynamics, to study connections between disease-related changes to heart tissue, rhythm disturbances and clot formation.

"The deep partnership between medicine and engineering drew me to the UW in 2018," Boyle says. "That doesn't exist everywhere, but it's critical to making an impact."

Above all, he feels a reawakened commitment to his work. "As long as I've studied this stuff, I've never had the chance to observe someone who's having an episode of A-fib," he says. "There's a lot of complex work ahead, but I feel a renewed vigor to help solve problems and advance heart health."

In the meantime, he's looking forward to enjoying more card games with his dad.

Author's note: I lost my dad in 2008 to a stroke. Though that was 15 years ago, not a day goes by that I don't think about him. My dad had a history of heart disease that I don't know much about. In fact, just a few months ago — while working on this story — I learned that my dad lived with A-fib. I'm thankful to Pat and his father for trusting me to help tell their story, and I'm grateful to the many researchers like Pat and his team who are working every day to better understand, treat and prevent heart disease and stroke.

Boyle plays cribbage with his father, Mike, and son, Clare.
Photo courtesy of the Boyle family

Learn more about Engineering Innovation in Health: **eih.uw.edu**

AN IV MONITOR TO HELP save newborn lives

By Wayne Gillam

According to the World Health Organization, the first month of life is the most vulnerable time for a child's survival. In 2020, 2.4 million children died in their first four weeks; the majority of those deaths took place in low- and middle-income countries.

"When I was in Malawi, I saw babies die — at one point, two to four babies a day. Most lost significant weight within two to three days after birth and became severely dehydrated without access to IV [intravenous] fluids," says Dr. Gregory Valentine, an assistant professor of pediatrics and neonatologist in the UW School of Medicine. "At the hospital in Malawi, there were not enough working IV pumps for all the babies. Even in developed countries, there currently isn't a low-cost IV monitor available that counts drops and can detect infusion rates as low as what is needed for a small and sick newborn."

Valentine consulted with medical colleagues in Malawi and, at the UW, he began working with Engineering Innovation in Health (EIH), a program that pairs engineering students with clinicians to address health-care needs. Denise Wilson, a professor of electrical and computer engineering (ECE) and an expert in sensor systems, also joined the team.

Through their collaboration, the team has engineered a low-cost, accessible and highly accurate IV fluid monitor.

"This project exposed me to the prototyping stages of product development, where we were directly involved with important design decisions," says ECE graduate student Jan Silva. "Working with the team and learning about the motivation for this project inspired me to continue pursuing projects in equitable and accessible health care."

IV fluids deliver hydration, nutrition and medications. These can be critical to sustaining life, especially for premature or sick newborns. But because of their small size, newborns receive far less fluid than older children or adults. This fact translates to a low, very slow IV fluid drip rate that can be difficult — in some cases impossible — to monitor with precision.

The research team's prototype, H2neO — which stands for "Hydration to Neonates" — is more accurate than comparable commercial IV monitors. H2neO is over twice as accurate at monitoring low drip rates and capable of monitoring drip rates that are lower than what can currently be detected.

"Most of the work that has been done on IV monitors has been done with adults in mind. But with newborns, any mistake in monitoring can have severe consequences," Wilson says. "There are tiny distinctions regarding when an actual drop is occurring, and therefore, this can create small sensing errors, which become a bigger percentage of the overall accuracy of the system with lower fluid rates. Our device, which was developed with newborns in mind, addresses these issues."

Graduate student Jan Silva adjusts the team's prototype. Photo by Ryan Hoover

A SPLASH OF COLOR

By Brooke Fisher

Photo courtesy of Erik Jepsen / UC San Diego

The phrase "a splash of color" took on a very literal meaning for a research team stationed in San Diego. Using environmentally safe pink dye, they are investigating the movement of water within a coastal zone, specifically where a river flows into the ocean.

"It's bright pink — we need it to be that bright," says Alex Horner-Devine, a professor of civil and environmental engineering, about the nontoxic dye. "We have to start with something concentrated so that we can see it get diluted for a long enough time to observe all the processes that mix it."

At the mouth of the Los Peñasquitos Lagoon estuary, where the freshwater river meets the ocean, the first of three dye releases kicked off on January 20. Although visible to the naked eye for only a few hours, smaller traces of dye can be detected with technology for up to 24 hours.

Until now, previous studies have primarily focused on investigating the dynamics of how freshwater from large rivers mixes with saline seawater. The Los Peñasquitos Lagoon was therefore selected as an example of a smaller river discharging into the ocean where it forms a plume — the resulting combined water mass.

Historically, river plumes have been studied by lowering instrumentation off the edge of boats, which isn't feasible this close to the shoreline. In addition to a variety of sensors installed at various ocean depths that measure everything from salinity to turbulence, the researchers are employing specialized equipment: GPS-tracked drifting sensors that record the trajectory of the river water and drones equipped with hyperspectral sensing.

By investigating the water movement dynamics, the researchers hope to better understand how various substances, especially pollutants, move from the nearshore area to outer waters.

Following the data gathering, the researchers will undertake further analysis and refine their computer models — which they hope will one day help manage coastal areas and prevent pollution events through enhanced prediction of dilution rates and transportation processes.

"One of the intriguing things about this research is that it falls between two disciplinary groups. For decades, people studying rivers always ignored waves and the people studying waves ignored rivers," says Horner-Devine. "The intersection of the two is actually a new area. A lot is known about wave breaking and river plumes, but little is known about how they interact with each other."

Quieting a bridge

By Lyra Fontaine

Washington's Evergreen Point Floating Bridge (SR 520 bridge) has expansion joints that allow it to expand or contract to adapt to environmental changes without causing structural damage. However, expansion joints can create noise problems.

When the SR 520 bridge opened in 2016, the constant sound of vehicles driving over its expansion joints became a nuisance for homeowners in the area. But engineering researchers have recently found a solution to the noise caused by the bridge.

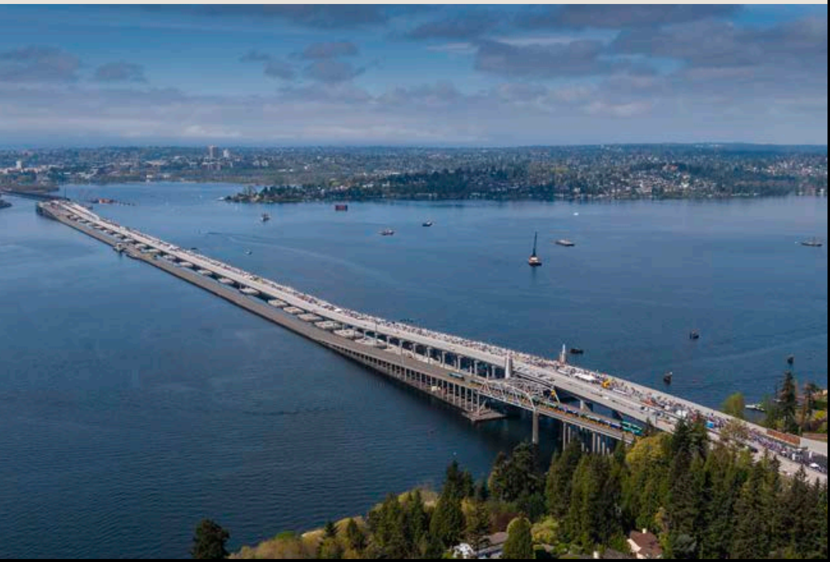
The project began in 2018, when the Washington State Department of Transportation (WSDOT) reached out to Per Reinhall, a mechanical engineering professor with expertise in removing noise in marine environments. His team measured the noise in the neighborhood and investigated its causes and how it spread. The team discovered the main noise sources were the resonance of the air within the expansion joint gaps and the vibration of the car tires.

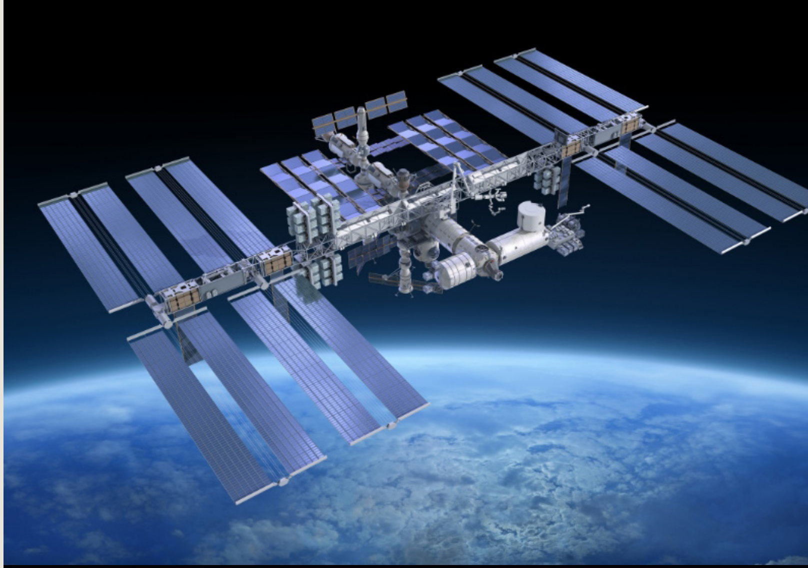
The team decided that a chevron rubber-like material would be the best option to fill in the gaps of the beams that create noise. Researchers installed the materials on one lane of the bridge and tested the treatment's performance through audio recordings.

"We lowered the noise level about 70 percent, or 10 decibels," says Reinhall.

The treatment held up well for several months, then started to disintegrate. This summer, Reinhall's team will begin investigating how to make the treatment more durable and will monitor it for the next few years to determine its success.

The Evergreen Point Floating Bridge (SR 520 bridge). Photo courtesy of WSDOT





Rendering of the International Space Station, where the film evaporation experiment will be tested.

A UW experiment heads to the ISS

By Amy Sprague

An experiment on film evaporation is heading to the International Space Station (ISS), thanks to support from the Center for the Advancement of Science in Space and the National Science Foundation. The project, which is being developed by an aeronautics and astronautics (A&A) team, will allow researchers to study film evaporation in a microgravity environment.

Liquid films have many practical uses including adhesives, coatings and cooling applications, specifically in semiconductor manufacturing. Knowing exactly how a film evaporates is crucial to improving these — and other — applications.

"Conducting experiments in microgravity essentially turns off the forces due to gravity so we can study other effects," says A&A Professor Jim Hermanson. "In the case of evaporating films, testing in microgravity removes buoyancy due to heating the film, allowing the study of other important phenomena, such as the effects of surface tension and mass loss, not easily studied on Earth."

For the experiment, the team will develop a pair of test chambers which will run in parallel — one aboard the ISS and one on Earth.

"Flying an experiment on the ISS is a big deal and takes years of detailed design, testing of components, and meeting stringent safety and operational requirements," Hermanson says. The team expects to see its hardware on the ISS in about four years.

A NEW FORM OF W commu

By Wayne Gillam | Photos by Ryan Hoover

Most types of wireless communication — such as what is found in your phone, garage door opener and keyboard mouse — transmit information back and forth by way of radio waves. Conventional radios generate clean signals that can send large amounts of data over long distances. However, it takes power to generate radio waves, and that can become costly for a device in terms of energy. To address this issue, researchers have been developing new forms of passive wireless communication, in which devices send information by reflecting pre-existing radio waves to greatly reduce energy consumption. Devices that use passive wireless communication methods such as ambient backscatter are often built to be battery-free, harvesting power from sources such as sunlight, broadcast television signals or environmental temperature differences.

Now, a UW team has achieved a dramatic step forward by demonstrating a wireless communication system that retains the benefits of passive wireless communication, while enabling devices to transmit data without relying on externally generated or ambient radio frequency signals.

“A big, practical limitation for low-power, passive wireless communication devices is that they depend on radio frequency sources. You can build these devices to be battery-free, but it can sometimes be difficult to use them because of needing to have an RF source or ambient signals nearby,” says Zerina Kapetanovic, who received her Ph.D. in electrical and computer engineering (ECE) last year. “It limits the application space, whereas I can set up the system we developed anywhere because it’s not dependent on having broadcast television towers in the vicinity.”

“A COMPLETELY NEW WAY TO COMMUNICATE”

This research was part of Kapetanovic’s dissertation, which she worked on with Joshua Smith, the Milton and Delia Zeutschel Professor in Entrepreneurial Excellence. Smith holds a joint appointment between ECE and the Paul G. Allen School of Computer Science & Engineering.

“What is really exciting is that this is a completely new way to communicate. When most wireless communication systems send information, they have to make a radio wave. For example, when I want to send information on my phone, it takes energy out of the battery and puts it into an oscillator. That oscillator connects to an amplifier and then into the phone’s antenna, where a radio wave comes out. It takes a lot of power to do that,” Smith explains. “Instead, we send information by controlling some thermal noise within the transmitter. When this noise is connected to the transmit antenna, the receiver sees a larger output signal; when it is disconnected, the receiver sees a smaller signal.”

The team’s prototype takes advantage of electronic noise generated by thermal agitation of charge carriers in circuits. This electronic jostling is present in all electrical circuits and is usually considered to be useless or a nuisance. In sensitive electronic equipment, noise can drown out weak signals and is almost always a limiting factor for electrical measuring instruments.

“In general, when we think about noise in wireless communication, it’s often viewed as a problem. It’s interference,” Kapetanovic says. “We’re actually showing the opposite here, that this particular type of noise can be used to enable communication.”

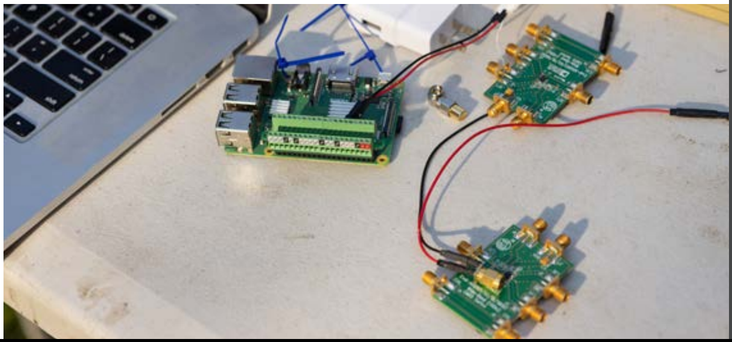
Above: Zerina Kapetanovic adjusts test equipment on the UW campus. Right: Examples of the team’s prototype.

FUTURE APPLICATIONS

Environmental monitoring and sensing in remote areas could be an important application of this form of wireless communication, in cooperation with other technologies — for example, improving farm productivity by deploying battery-free sensors that detect and send information about soil moisture and temperature levels. Another possible application area is the Internet of Things, where battery-free devices that don't need to rely on pre-existing radio signals could contribute to the design of smart home security systems, appliances, lighting fixtures and thermostats.

But perhaps one of the most important things about this new form of wireless communication is that it opens a new line of research possibilities.

"One of the things that I've been working on for a long time is creating sensors and other devices that could run forever without batteries, using only harvested power from the environment," Smith says. "This is something that could very well help make that happen. Plus, I have a page-long list of other research projects I want to do that grows out of this work."



RESEARCH UPDATES

AI for children with speech and language disorders

Julie Kientz, professor and chair of human centered design and engineering, is the UW lead on a new multi-campus institute that will develop artificial intelligence (AI) technologies for children with speech and language processing challenges. Housed at the University at Buffalo and funded by the National Science Foundation, the AI Institute for Exceptional Education will work to create advanced AI systems that support earlier diagnoses of speech and language processing challenges and allow for customized educational interventions.

Innovation in distributed computing

Distributed computing advances have spurred innovation with the use of large, intensive applications — but at a high cost in terms of energy consumption and environmental impact. The Allen School's Arvind Krishnamurthy and Michael Taylor, who holds a joint appointment in the Allen School and electrical and computer engineering, are contributing to a multi-university effort focused on tackling these challenges. The ACE Center for Evolvable Computing will foster the development of computing technologies that improve the performance of microelectronics and semiconductors while advancing distributed computing technology and furthering innovation in the semiconductor industry.

Advancing transportation research

The Pacific Northwest Transportation Consortium (PacTrans) has received a five-year $15 million renewal grant from the U.S. Department of Transportation to expand its work to improve the movement of people and goods throughout the region. Directed by Yinhai Wang, a professor of civil and environmental engineering, PacTrans supports transportation research projects related to mobility, education and workforce development, and is focused on economic strength, global competitiveness, equity, transformation and safety.

Read more research news at **engr.uw.edu/news**

ADVANCING

UW CREATE collaborates toward a world with fewer problems and more solutions for people of all abilities.

By **Alice Skipton**

According to the Centers for Disease Control and Prevention (CDC), one in four people in the United States lives with a disability. "The presence of disability is everywhere," says Heather Feldner, UW Medicine assistant professor in Rehabilitation Medicine and associate director with the UW Center for Research and Education on Accessible Technology and Experiences (CREATE). "But how disability has been constructed, as an individual problem that needs to be fixed, leads to exclusion and discrimination."

The construct also ignores the reality that people's physical and mental abilities continually change. Examples include pregnancy, childbirth, illness, injuries, accidents and aging. Additionally, assuming that people all move, think or communicate in a certain way fails to recognize diverse bodies and minds. By ignoring this reality, technology and access solutions have traditionally been limited and limiting.

UW CREATE, an applied research center, exists to counter this problem by making technology accessible and the world accessible through technology. Launched in early 2020 with support from Microsoft, the Center connects research to industry and the community. On campus, it brings together accessibility experts and work-in-progress from across engineering, medicine, disability studies, computer science, information science and more, with the model always open to new collaborators.

"Anyone interested in working in the area of accessible technology is invited to become part of CREATE," says Jacob O. Wobbrock, a professor in the UW Information School and one of the founders and co-director of the Center.

SHOOTING FOR THE MOON

"We have an amazing critical mass at UW of faculty doing accessibility research," says Jennifer Mankoff, a professor in the Paul G. Allen School of Computer Science & Engineering and a co-founder and co-director of CREATE. "There's also a lot of cross-talk with Microsoft, other technology leaders, and local and national community groups. CREATE wants to ensure people

Above: CREATE is partnering with UW I-LABS to explore how accessibility impacts young children's development, identity and agency. Photo courtesy of UW CREATE

Opposite page: Many CREATE projects focus on mobility and mobile device accessibility.

joining the workforce know about accessibility and technology and that the work they do while they are at UW directly and positively impacts the disability community."

The concept of moonshots — technology breakthroughs resulting from advances in space exploration — offers a captivating way of thinking about the potential of CREATE's research. The Center currently has four research moonshots for addressing technological accessibility problems. One focuses on how accessibility impacts young children's development, identity and agency and includes a mobility and learning study with the UW Institute for Learning & Brain Sciences (I-LABS) that employs the only powered mobility device available in the U.S. market specifically designed for children one to three years old. Another looks more broadly at mobility indoors and outdoors, such as sidewalk and transit accessibility. A third seeks ways to make mobile and wearable devices more accessible along with the apps people use every day to access such essentials as banking, gaming, transportation and more. A fourth works toward addressing access, equity and inclusion for multiply marginalized people.

ACCESS

For CREATE, advancing these moonshots isn't just about areas where technologies already exist, like improving an interface to meet more people's needs. It's about asking questions and pushing research to address larger issues and inequities.

"In certain spaces, disabled people are overrepresented, like in the unhoused or prison populations, or in health-care settings," Mankoff says. "In others, they are underrepresented, such as in higher education, or simply overlooked. For example, disabled people are more likely to die in disaster situations because disaster response plans often don't include them. We need to ask how technology contributes to these problems and how it can be part of the solution."

BROADER PROBLEM-SOLVING ABILITIES

CREATE has situated these research moonshots within a practical framework for change that involves education initiatives, translation work and research funding. Seminars, conversations, courses, clubs and internship opportunities all advance the knowledge and expertise of the next generation of accessibility leaders. Translation work ensures that ideas get shaped and brought to life by community stakeholders and through collaborations with UW entities like the TASKAR Center for Accessible Technology, HuskyADAPT and the UW Disability Studies Program, as well as through collaborations with industry leaders like Microsoft, Google and Meta. CREATE's research funding adds momentum by supporting education, translation and direct involvement of people with disabilities.

Nicole Zaino, a mechanical engineering Ph.D. student participating in CREATE's early childhood mobility technology research, describes the immense benefits of having her education situated in the context of CREATE. "It's broadened my research and made me a better engineer," she says. She talks about the critical importance of end-user expertise, like the families participating in the mobility and learning study. Doing collaborative research and taking classes in other disciplines gives her more insights into intersecting issues. That knowledge and new vocabulary inform her work because she can search out research from different fields she otherwise wouldn't have known about.

Seeking to push progress further, CREATE has an initiative on research at the intersection of race, disability and technology with several campus partners. CDC statistics show that the number of people experiencing a disability is higher when examined through the lens of race and ethnicity. With events and an open call for proposals, the initiative seeks increased research and institutional action in higher education, health care, artificial intelligence, biased institutions and more.

"If we anticipate that people don't conform to certain ability assumptions, we can think ahead," says Wobbrock. "What would that mean for a particular technology design? It's a longstanding tenant of accessibility research that better access for some people results in better access for all people."

Keep up with UW CREATE at **create.uw.edu**

PARTNERSHIPS

CAPSTONE COLLABORATIONS

By Chelsea Yates

Launched in 2017, the College's Industry Capstone Program pairs students with companies, nonprofits and government organizations to tackle real-world engineering challenges.

Many of the capstone projects exemplify the College's commitment to engineering excellence for the public good — that engineering education prepares students to help shape a healthier and better world.

"It's a win-win for everyone involved," says Jill Kaatz, who directs the program. "Organizations that sponsor projects get to work with creative engineering students and faculty, who can provide a fresh look at a challenge. It can also be a great way to build brand recognition with up-and-coming engineers. Students benefit by working side-by-side with industry representatives on real-world problems. It's like on-the-job experience in the classroom."

College leaders worked closely with industry partners to develop the program. "We heard from College Advisory Board members and industry partners who were eager to engage more directly with students," says David Iyall, the College's associate dean of advancement.

Prior to this program, partnership opportunities for organizations consisted mostly of sponsored research, which often requires a significant investment. The Industry Capstone Program gives organizations a manageable and accessible way to tap into the College's strengths — at a fraction of the cost.

Industry partners have ranged from well-known, established companies to startups, nonprofits and government organizations. Last year, the program hosted 95 projects supported by 62 sponsors, with more than 400 participating students.

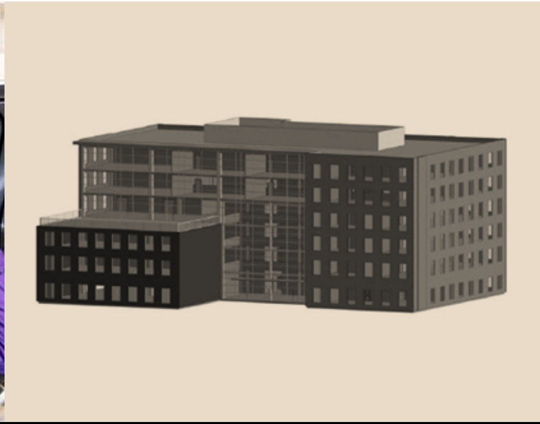
Program directors are excited for these numbers to grow. While they're interested in receiving more project proposals, they say that some project types work better than others.

"Projects that would be appropriate for entry-level engineers are generally a good fit, as are those that reflect real but not mission-critical problems for your organization," Kaatz says.

Have an idea for a capstone project? Visit **engr.uw.edu/industry/capstone** to partner with us!

Above: Engineering students present their capstone projects. Photo by Ryan Hoover

Below, left: Students explore charging issues with a 2023 Ford Mach E GT. Photo by Dennis Wise. Center: A vertical evacuation structure designed by students for Fife City Hall. Right: Students present their work on air travel accessibility.



SPOTLIGHT ON RECENT PROJECTS

Improving the electric vehicle charging experience

A big hurdle to getting more electric vehicles (EVs) on the road is access to public charging networks. Currently most EV drivers charge their vehicles at home and use their EVs for in-town driving only. The lack of fast, reliable charging stations on highways is a frequent concern, as is running out of power with nowhere to charge.

Today there are only about 50,000 EV charging station locations nationwide, compared to 150,000 gasoline station locations. To reduce dependency on gas- and diesel-powered vehicles and to meet climate policy goals, more charging locations are needed along with infrastructure changes.

This year, the Ford Motor Company and business consulting firm Envorso have enlisted the help of UW students to create the ideal EV charging experience. The team has been working with a 2023 Mach E GT to explore a range of issues related to charging. This year's team is focused on one aspect of the challenge; the long-term goal is to develop an end-to-end plan for the charging experience of tomorrow — from modeling in-vehicle hardware and software enhancements that will improve battery capacity and range to making recommendations for grid integration and infrastructure updates.

A roadmap to accessible air travel

There aren't spots for wheelchairs on airplanes today. According to All Wheels Up, a nonprofit dedicated to making air travel accessible, many wheelchair users avoid air travel due to inaccessibilty. Those who do must check their wheelchairs, use transfer wheelchairs in the airport and be wheeled by wheelchair agents onto airplanes. At the flight's end, they must wait for other passengers to deboard and for wheelchair agents to retrieve another transfer wheelchair until they're reunited with their own. That wait can be nerve-wracking: the nonprofit reports that wheelchairs are frequently damaged during transport.

All Wheels Up wants to make it possible for people to travel on planes in their own electric wheelchairs, similar to how people travel on buses. Yet moving from idea to implementation is no easy feat. Currently there aren't standards for crash-testing wheelchairs, nor are there FAA guidelines for wheelchairs and securement. There's also the challenge of getting buy-in from numerous stakeholders, including wheelchair users, airline companies, airports, advocacy groups, manufacturers and the FAA.

To outline a plan, All Wheels Up enlisted the help of engineering students, who developed an easy-to-understand guide on how to move from where we're at today — no standards or spots for wheelchairs on planes — to research and development, certification and, ultimately, implementation. The guide is being used to inform conversations with the FAA and lawmakers.

Fife City Hall evacuation structure and planning

Fife, Washington, lies in the Puyallup River valley which has, over geological time, been subject to lahars and tsunamis. There's a risk that these events could occur again, particularly in the case of a major earthquake in the Cascadia Subduction Zone, which could trigger both a tsunami and a lahar. In that case, the tsunami might hit Fife within 15 minutes after the earthquake and the lahar less than an hour after that. Despite these risks, Fife's proximity to the Port of Tacoma and Interstate 5 has led to substantial development of the city, which is now home to approximately 11,000 residents.

For this project, the City of Fife partnered with engineering students on programming and preliminary design of a new City Hall building and sitework, which included a vertical evacuation structure for potential lahar and tsunami events. This would allow people to evacuate above the level of tsunami inundation. The team prepared conceptual plans and documents for buildings to house City Hall, police and court functions, as well as to serve as vertical evacuation structures that could protect occupants in the event of a lahar.

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Courtesy of KieranTimberlake. Rendering is conceptual and may not represent the final look of the building.